Preliminary Team Response to FAQ 06-0017
on NUREG/CR-6850, EPRI TR-1011989

Final Revision – 6/19/2007
Prepared by: S. Nowlen, B. Najafi, D. Funk, F. Joglar and M. Kazarians

Summary of the FAQ

FAQ 06-0017 suggests an alternate method for counting low voltage cabinets for the purposes of the high energy arc fault (HEAF) frequency analysis. The apparent intent is to assign a larger fraction of the total plant-wide HEAF fire frequency to medium voltage equipment and away from low voltage equipment arguing that this is more representative of the fire event data set. The FAQ as provided to the EPRI and RES teams is attached to this document for reference.[1]

Summary of Team Response

The team disagrees with the proposed resolution for switchgear and load centers, but agrees that some adjustment of the frequency of HEAF events between low- and medium-voltage panels may be appropriate. An alternate solution is offered that re-calculates HEAF frequencies separately for low-voltage and for medium-voltage equipment. This should achieve the intent of the FAQ but the proposed team solution stands on a more defensible technical basis and maintains consistency with other aspects of the methodology.

Detailed Response and Basis

With respect to counting of electrical panels for the purposes of the HEAF fire events, the team disagrees with the proposed alternate counting method for load centers and low voltage switchgear. Our disagreement is based on the fact that no clear rules of application have been specified so that it may not be applied consistently by analysts. The counting approach also appears rather arbitrary. That said, the state of knowledge regarding HEAF fires continues to evolve. New insights developed since publication of the methodology do indicate that an adjustment of fire frequencies between low- and medium-voltage equipment is warranted.

The electrical power community has, over the past two years, gained significant knowledge about HEAFs. This increased awareness and knowledge base was driven by adoption of new arc flash protection requirements in NFPA 70E, *Standard for Electrical Safety Requirements for Employee Workplaces*. Discussions with experts close to the subject, including a member of the IEEE 1584 standards committee (*Guide for Performing Arc-Flash Hazards Calculations*) revealed that recorded events of HEAFs are actually dominated by incidences involving 480V gear. The experts confirm that the

[1] Note that the original FAQ included a question on the counting and treatment of bus bar fires. This aspect of the question was deleted in a revision of the FAQ and is not included in this response. The attached FAQ is the original version provided to the team for consideration.

higher incidence of 480V events is partially attributable to the greater population of installed 480V equipment. However, other overlapping factors are also important:

- A majority of arc flash events are initiated by human error.
- Low voltage equipment is worked on/operated more frequently than medium voltage equipment.
- Workers have a more casual attitude when working on 480V gear, i.e., everyone knows that you will probably not get a second chance if you make a mistake working on medium voltage equipment but they tend to perceive 480V gear as less threatening. Additionally, it is more probable that 480V equipment will be worked "hot"; that is, worked on while the equipment is energized.
- Basic design attributes of medium voltage gear decrease the likelihood of initiating a sustained arcing fault. Key elements include insulated bus bars in lieu of open bus bar work, barrier protection, compartmentalization between phases, and increased creepage distances.
- Arcing faults do occur on 208V systems; however, sustained arcing faults at 208V are rare and difficult to reproduce.

With these observations in mind, the intent of the HEAF analysis (per Appendix M) is to capture "higher-consequence" events that may have a *substantive impact outside the cabinet of origin*. Other arc fault events (e.g., events that did not lead to an impact outside the originating panel) are already treated via the general electrical panel fire frequency and this treatment need not be adjusted. Only the "higher-consequence" events are under question here.

Another observation that is evident from the event records amassed by the IEEE standard groups is that, even though the general incidence of arc faults in low-voltage equipment may actually be higher, the fraction of such events leading to substantive impacts outside the initiating cabinet (i.e., higher-consequence events) is actually lower than for similar incidents in medium-voltage equipment. In essence, if a sustained arc fault occurs in a 4.16 kV switchgear, the fault will very likely have an impact beyond the limits of the panel. In contrast, an arc fault in a low voltage panel is more likely to remain confined to the panel and less likely to have impact beyond the panel. This rationale is supported by standardized arc flash calculations; equivalent stand off distances are typically greater for medium voltage equipment, given normal and customary overcurrent protection.

This contention is consistent with both the broader industry experience and with the specific nuclear industry experience as cataloged in Appendix M. That is, the frequency analysis included three events in medium-voltage equipment, and only ½ of an event (i.e., one uncertain event) for low-voltage equipment. This assessment included consideration of whether each reported event actually had impact outside the panel of origin. There are many other low-voltage panel fire events that appear to have involved some degree of arc-flash, but that also remained confined to the panel of origin.

The team's proposed resolution to the underlying issue raised in the FAQ is to split fire ignition frequency Bin 16, HEAF, into two bins; namely, "16a – HEAF for low-voltage panels (480-1000V)" and "16b – HEAF for medium-voltage panels (greater than 1000V)." For each bin, the method of panel counting would then stand unchanged (i.e., count vertical sections). Given the split into two bins, the counting method, and hence the fire frequency apportioning process, need to be self-consistent within each of the two new bins, but there is no longer any cross-over between the low- and medium-voltage equipment. This also maintains consistency with the counting method for general thermal fires (i.e., the non-HEAF panel fires that must also be treated) which is also a highly desirable feature so that analyst need not maintain two separate population counts for the same set of fire ignition sources.

The net result is a re-partitioning of the "higher-consequence" HEAF events between low and medium-to-high voltage equipment in accordance with the event data. The revised fire frequencies for these two new bins are as follows:

16a: HEAF for Low- Voltage Panels (480 – 1000 V)	
Mean	4.8E-04
Variance	1.4E-03
5%	1.6E-05
50%	2.0E-04
95%	1.5E-03

16b: HEAF for Medium-Voltage Panels (greater than 1000 V)	
Mean	1.4E-03
Variance	1.2E-02
5%	3.8E-05
50%	6.2E-04
95%	4.1E-03